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Wounds and weapons

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Abstract

Purpose: X-ray findings are described, which are typical for injuries due to conventional weapons. It is intended to demonstrate that radiographs can show findings characteristic for weapons.
Material and method: The radiograms have been collected in Vietnam, Croatia, Serbia, Bosnia, Chad, Iran, Afghanistan, USA, Great Britain, France, Israel, Palestine, and Germany.
Results: Radiograms of injuries due to hand grenades show their content (globes) and cover fragments. The globes are localized regionally in the victim's body. Survivors of cluster bombs show singular or few globes; having been hit by many globes would have been lethal. Shotguns produce characteristic distributions of the pallets and depth of penetration different from those of hand grenades and cluster bombs; cover fragments are lacking. Gunshot wounds (GSW) can be differentiated in those to low velocity bullets, high velocity projectiles, and projectiles, which disintegrate on impact. The radiogram furnishes the information about a dangerous shock and helps to recognize the weapon. Radiograms of victims of explosion show fragments and injuries due to the blast, information valid for therapy planning and prognosis. The radiogram shows details which can be used in therapy, forensic medicine and in war propaganda – examples could be findings typical for cluster bombs and for dumdum bullets; it shows the cruelty of the employment of weapons against humans and the conflict between the goal of medical care and those of military actions.
Conclusion: Radiographs may show, which weapon has been employed; they can be read as war reports.

Keywords: Radiology of war; Hand grenade; Gunshot wounds; Cluster bombs; Shotgun injuries; Blast injuries

1. Introduction

The radiogram shows wounds; it visualizes the extent and the severity of the injury; furthermore it proves the bodily harm. The radiogram is part of the therapy and serves to rate the patient's chances.

Radiograms are an instrument of therapeutic medicine; less known is the fact that their analysis contributes to resource planning in war:

- Radiograms allow recognising the employed weapons and the introduction of new weapons, which is important for the planning of treatment and transport of injured soldiers and civilians in the future. The information that new weapons have been introduced may even be of value for the officer planning attack or retreat;
- Radiograms furthermore secure evidence that weapons have been employed, which includes proscribed and forbidden arms. In consequence, they have abilities to be used in propaganda warfare.

In the following, X-ray findings shall be described which are typical for wounds due to conventional weapons.

2. Material and method

The radiograms come from:

- Hanoi, Vietnam;
- Zagreb, Croatia;
- Belgrade, Serbia;
- Sarajevo, Bosnia;
- N'djamena, Chad;
- Iran;
- Afghanistan;
- USA;
- Great Britain;

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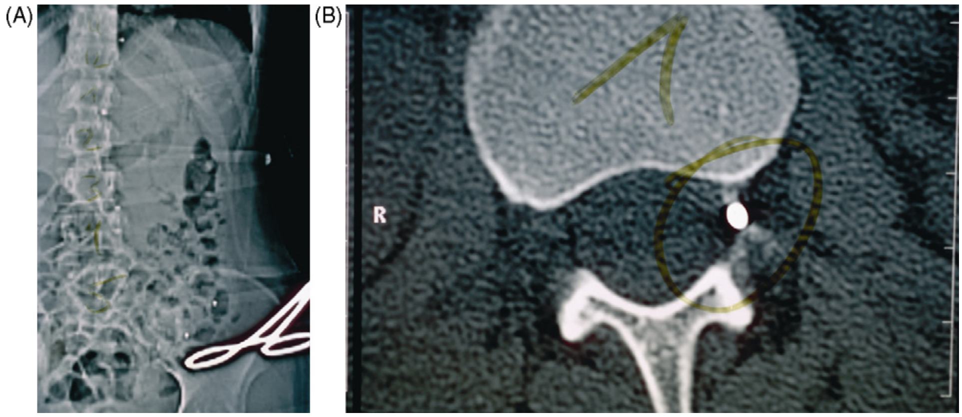

Fig. 3.1.1.1. A and B: pellet (globe) near the spinal cord. Hand grenade injury, gang fighting, disco Hamburg. CT, topogram and axial cut.

- France;
- Israel;
- Palestine;
- Germany.

Physicians from these countries permitted the author to review their collections and the archives of their hospitals, and copying images for analysis and evaluation. They helped with explications and comments, offered additional and background information and discussed the possibilities and limits of diagnostic imaging in war and crime - overviews have been published in books [1]; the following presentation is based on the generous contribution of these colleagues and friends.

Images have been chosen, which show X-ray findings typical for conventional weapons, and which allow guessing which

Fig. 3.1.1.2. Pellets (globes) and cover fragments. Hand grenade injury, Croatia.

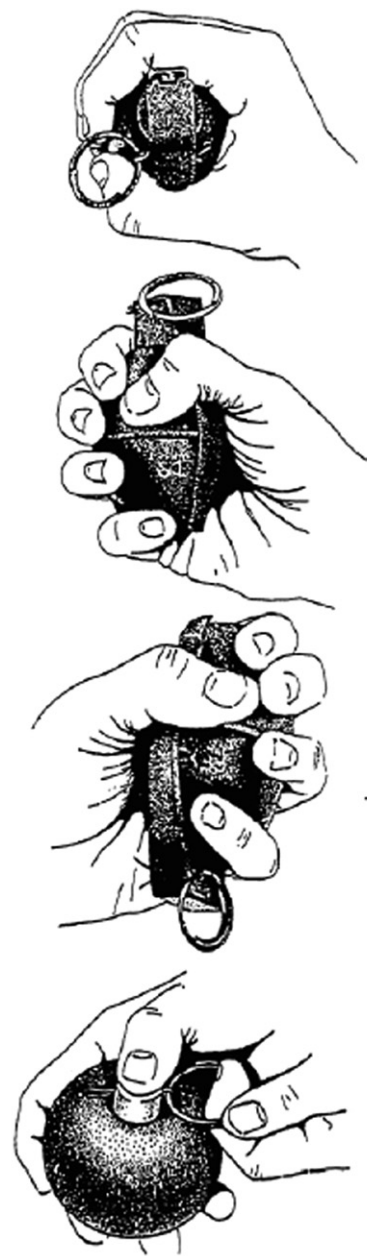

Fig. 3.1.1.3. Holding a hand grenade.

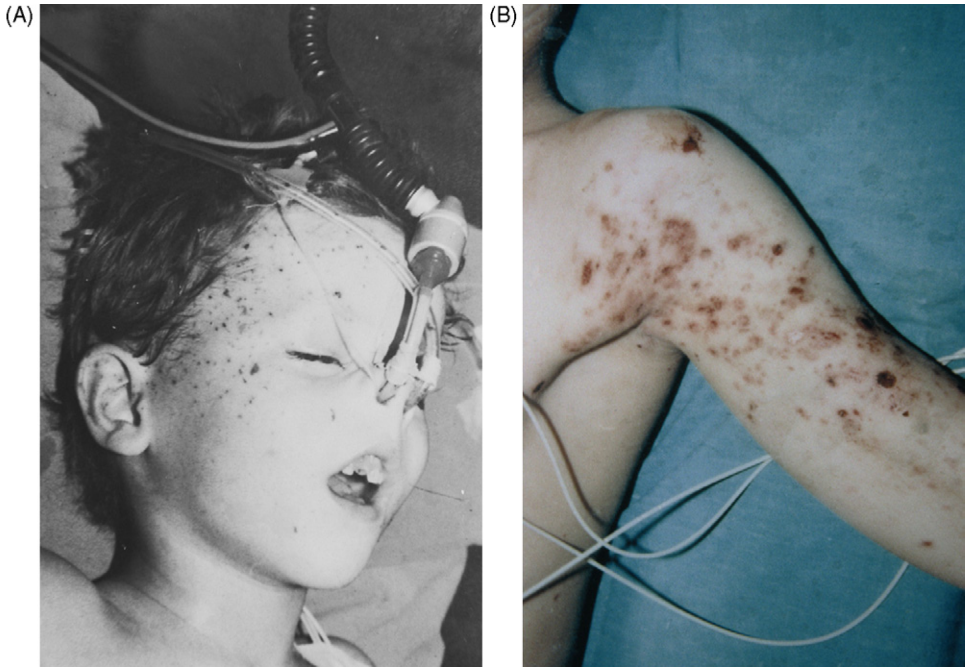

Fig. 3.1.1.4. A and B: injuries due to the explosion of a hand grenade, when playing around. Child, Croatia.

weapons have been used. Details will be demonstrate, which permit to identify the employed weapons.

3. Results

Injuries due to conventional weapons can be separated in those by fire arms, and arms acting by explosives. Multiple combinations are known. Of interest for the radiologist are those, which induce typical or even characteristic findings. This is to a certain degree valid for the:

- pellets of weapons of dispersion;
- projectiles of fire arms;
- blast effects of explosives.

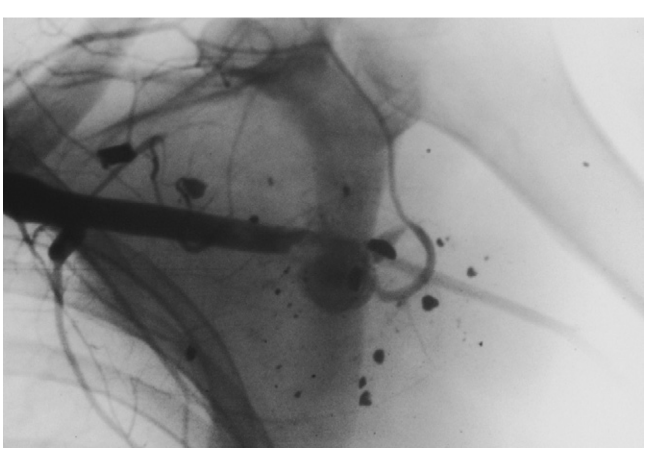

Fig. 3.1.1.5. Occlusion of the axillary artery; pellets (globes) and cover fragments. Hand grenade injury, Croatia.

Pellets (globes) are an essential part of the load of weapons of dispersion. Before entering the body, they have been accelerated by an explosive charge or by the charge of a cartridge (shot pellets, buck shot). In general, the pellets (globes) consist of metal, often plumb; therefore they are easily visualized on radiograms. The envelope is composed of plastic or metal; its fragments might be seen in the X-ray film.

Fig. 3.1.1.6. Traumatic aneurysm of the popliteal artery. Pellets (globes). Hand grenade injury, Croatia.

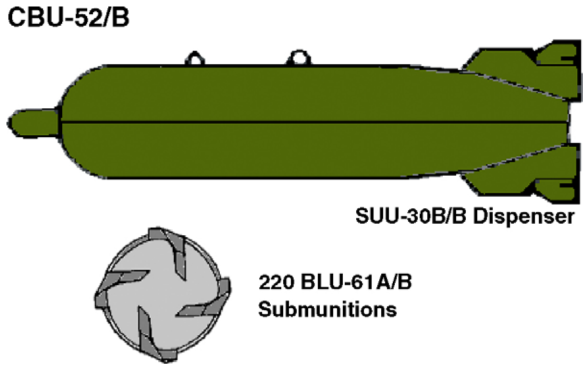

Fig. 3.1.2.1. Carrier (dispenser, mother bomb) with submunition which has a guiding device.

3.1.1. Hand grenade

Hand grenades are used not only in war, but also in terror attacks and in crime (Fig. 3.1.1.1). In war they are weapons of attack and of defence, which means that offensive and defensive hand grenades have been designed and are employed. Offensive hand grenades have a larger range of impact than the defensive ones: the purpose of action explains the design: a hand grenade, which is meant to be used against an attacker, has a range of action determined by the distance between the defender and the attacker; usually, this distance is smaller than that between the distance between the attacker, who throws the hand grenade, and a (possibly surprised) attacked defender.

The radiogram shows in the body the globes, which have been the load of the hand grenade and the fragments of the cover, if the cover has been of metal (Fig. 3.1.1.2).

Fig. 3.1.2.2. Submunition (daughter bombe, "*bombe fille*"), which has not exploded, Vietnam.

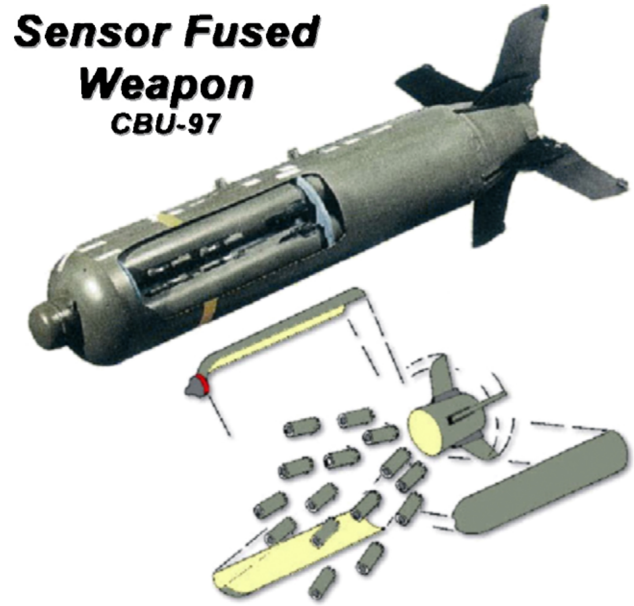

Fig. 3.1.2.3. Carrier with target seeking submunition with parachute and steering gear.

Fig. 3.1.2.4. Injury of the arm. Cluster bomb victim, Vietnam.

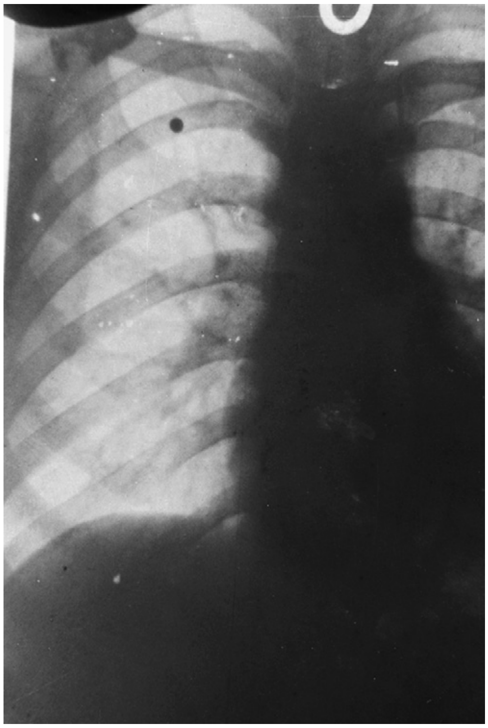

Fig. 3.1.2.5. Injury of the chest. Cluster bomb victim, Vietnam.

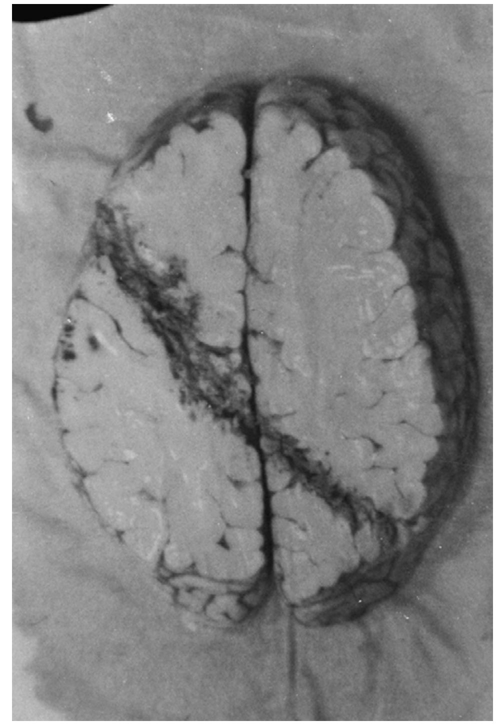

Fig. 3.1.2.7. Necropsy. Path of a pellet (globe) in the brain. Cluster bomb victim, Vietnam.

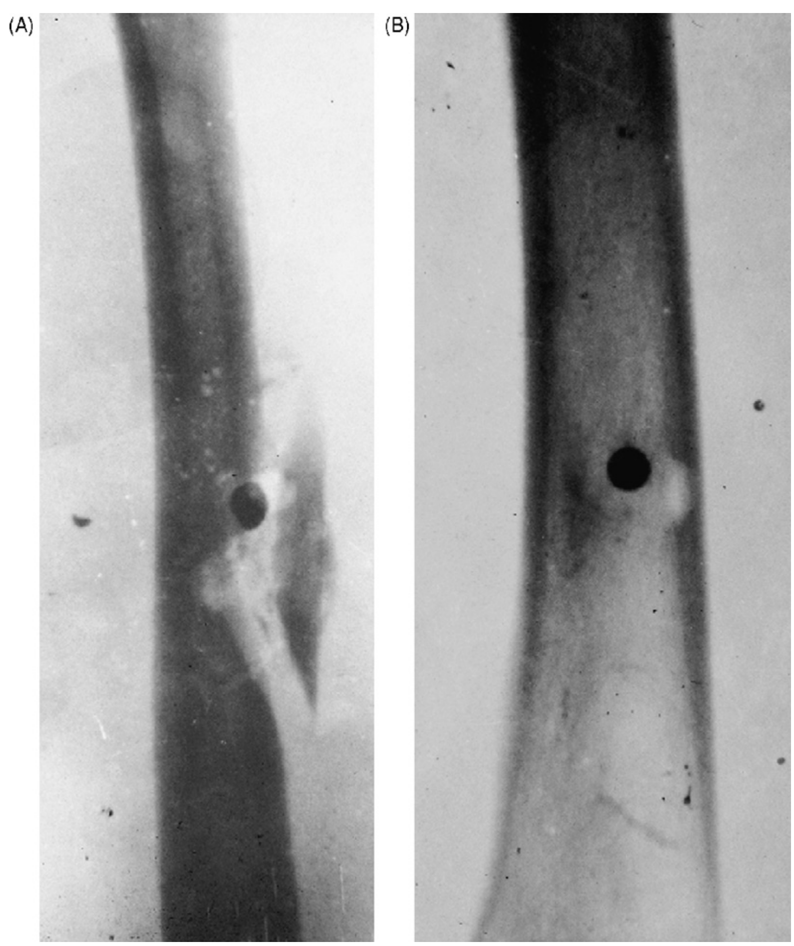

Fig. 3.1.2.6. A and B: injury of the bone. Cluster bomb victim, Vietnam.

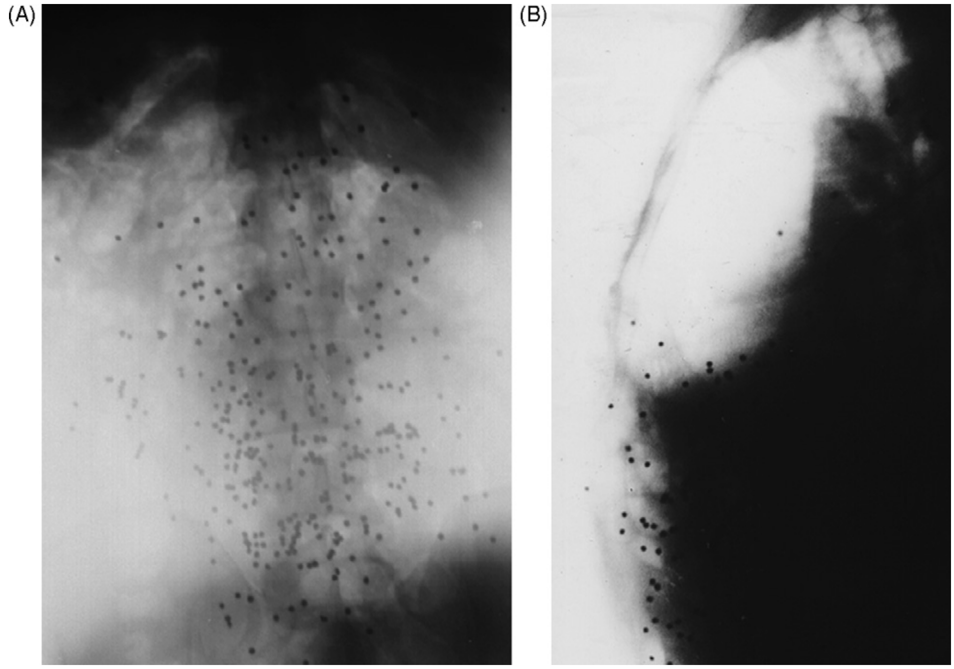

Fig. 3.1.3.1. Size of the dispersion of the shot globes (A); penetration is shown in the frontal projection (B). Radiogram of the trunk. Shotgun injury.

In general, hand grenades have a security pin, which prevents the explosion. After releasing the safety, the grenade explodes in a set time (Fig. 3.1.1.3).

Hand grenades, which do not explode and lie around, endanger civilians. Children take them up and try to draw the security pin. The resulting explosion can kill or mutilate (Fig. 3.1.1.4A and B).

Depending of the localization of the pellets (globes) and of the clinical picture, conventional plain film diagnostic and computed tomography will be combined with special imaging methods. Angiography can show the occlusion of a vessel (Fig. 3.1.1.5) or the formation of a traumatic aneurysm (Fig. 3.1.1.6).

3.1.2. Cluster bombs

Cluster or splinter bombs consist of a carrier (dispenser, mother bomb, "*bombe mère*" (Fig. 3.1.2.1) and submunition (daughter bomb, "*bombe fille*", Fig. 3.1.2.2). The carrier releases

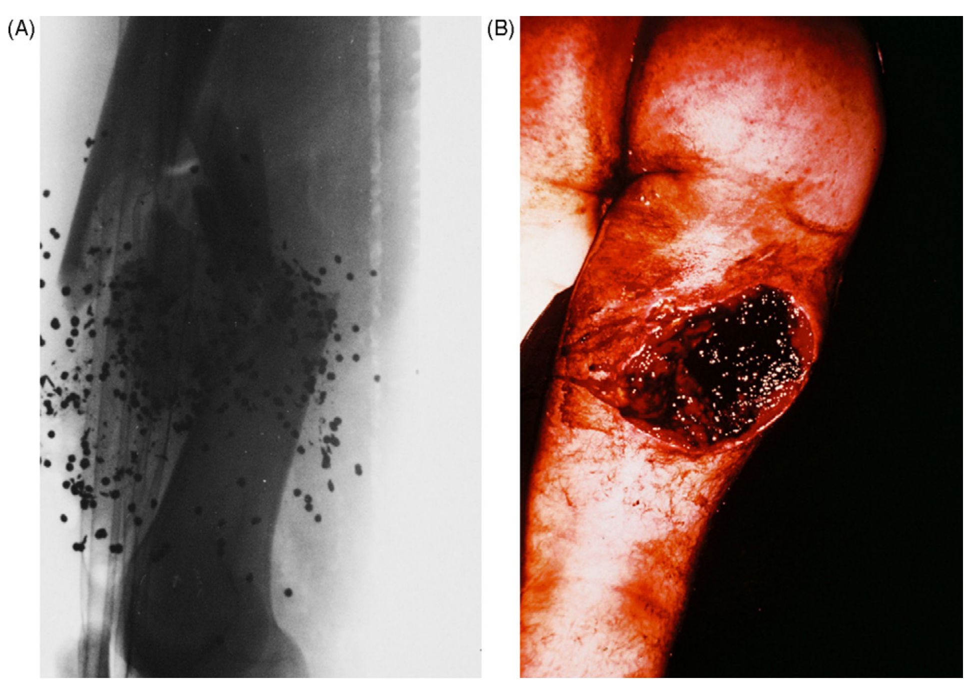

Fig. 3.1.3.2. A and B: depth of penetration, upper leg.

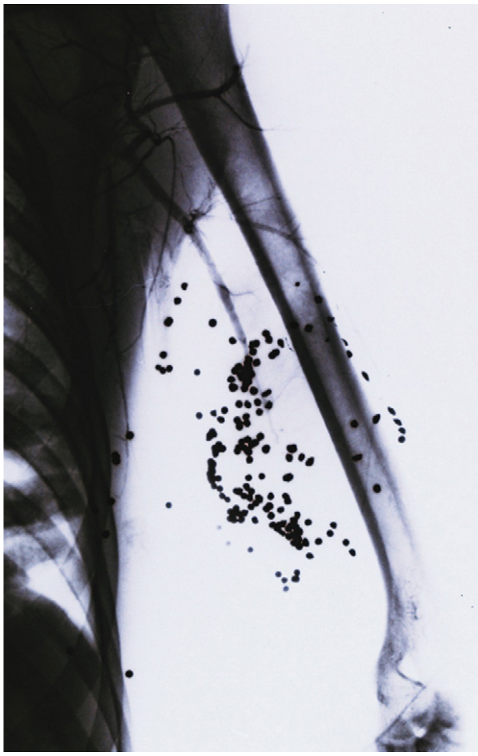

Fig. 3.1.3.3. Size of dispersion of the shot pellets (globes), arm.

Fig. 3.1.3.5. Face injury with self made shot due to the burst of the self made shooting device, Columbia.

the submunition above the target area. The submunition explodes on impact. From the military standpoint, cluster bombs are highly effective. With high reliability, one carrier kills all unprotected persons in the target area, which can have the size of a football field.

Submunition may have a special target guide (Fig. 3.1.2.3) for example a steering gear or a parachute. Depending upon the type of target, explosive (blast) effects or multi-fragments (mostly bullets) may be chosen. These weapons permit effective blocking of supply lines or special areas, otherwise only possible with landmines. This is being achieved by submunition, which does not explode upon impact, but only by activation of target-specific sensors. Stabilizing wings etc. are external features, easily mistaken for toys by children, when finding not yet detonated submunition. These "duds" are similar to toys, therefore the media report regularly about weapons designed as toys with the intention to harm children.

Radiograms from victims of cluster bombs are rare; this is explained by the fact, that in war only rarely corpses are X-rayed and survivors are the exception; survival is only possible with some sort of protection. X-ray films show therefore only singular or few globes (Figs. 3.1.2.4–3.1.2.6). The pellets (globes) and

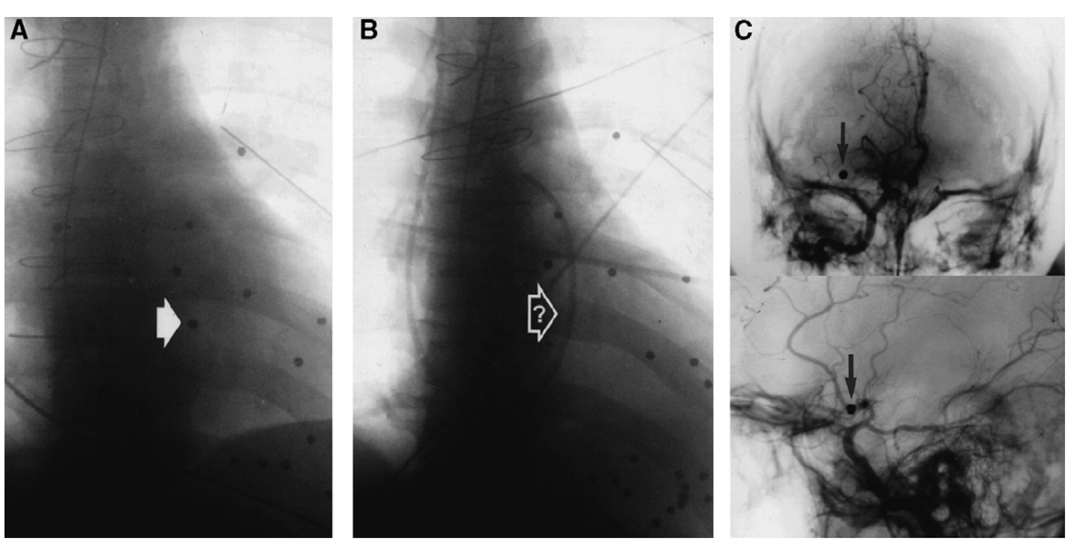

Fig. 3.1.3.4. A: injury by shot of the chest. B: hemiplegia. One pellet in the chest is missing (arrow). C: angiography localizes the pellet in the medial cerebral artery [1].

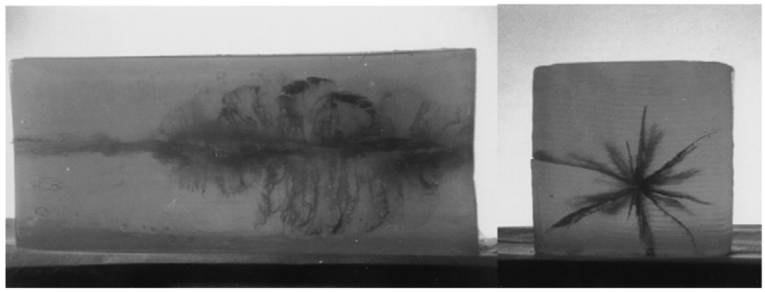

Fig. 3.2.1.1. A and B: high velocity projectile shot into a block of gelatine: sonic boom producing a cone of destruction with the apex at the bullet's point of entrance.

Fig. 3.2.1.2. High velocity gunshot wound. The destruction surpasses the path of the projectile. Dots (splinters) of the projectile's jacket can be seen in a remarkable distance to the projectile's path.

splinters have a low speed; in the body, the injury is limited to its path (Fig. 3.1.2.7).

3.1.3. Shotgun injury

Shotgun injury is included because the X-ray findings of victims of shotgun injuries have some similarities with those of hand grenades and cluster bombs. However, shotguns are only exceptionally employed in military conflicts. They are used in civil wars, if available; civil wars are characterized by the use of every available weapon. Shot-ammunition (pellets) disperses with the distance. In crimes, this can be used to reconstruct the events (Fig. 3.1.3.1A and B). The depth of penetration depends among others from the size of the shot pellets, and their velocity (firing distance) (Figs. 3.1.3.2 and 3.1.3.3Figs. 3.1.3.2 A and B and 3.1.3.3).

Fig. 3.2.1.4. Snowstorm produced by unjacketed bullet from a high velocity hunting rifle [1].

Shot of different size is used. In forensic medicine, there is an important difference between shot pellets and other projectiles: the shot pellets do not show a surface pattern characteristic

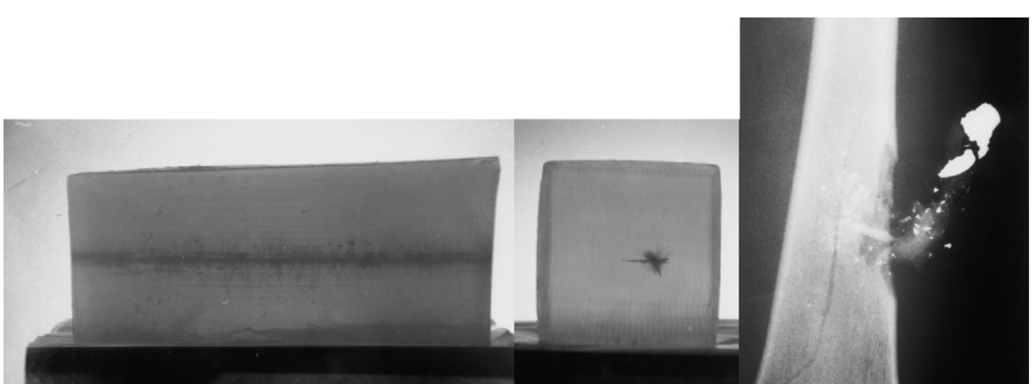

Fig. 3.2.1.3. A–C: destruction of a gelatine block of a low velocity bullet and of an upper leg.

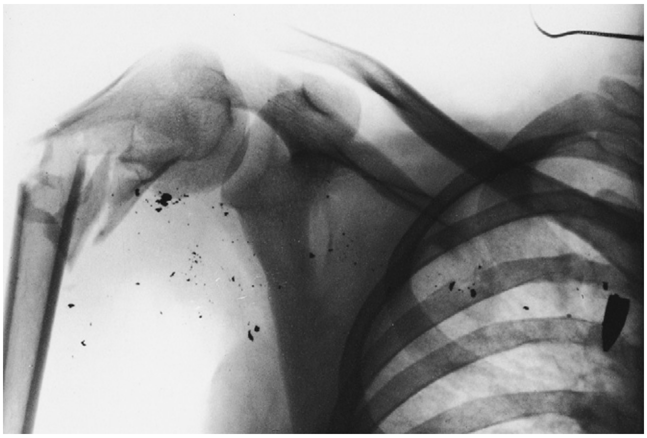

Fig. 3.2.2.1. Overturn of a jacketed projectile.

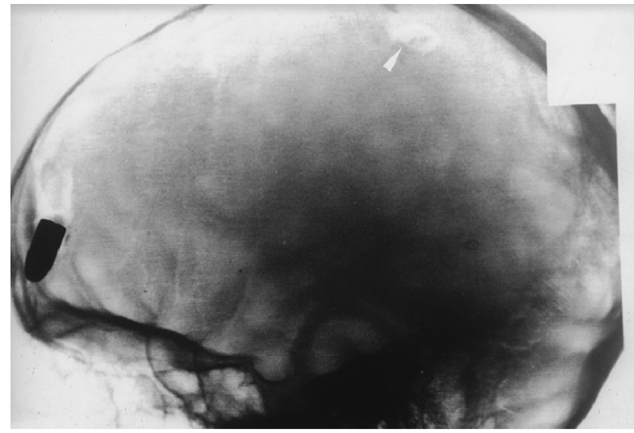

Fig. 3.2.2.3. Tangential deflection following the inner contour of the calvarium.

for the shotgun, which could help to identify the weapon. Colleagues in Northern Ireland reported that this was the reason for terrorists of both sides to employ shotguns, and to avoid the use of other firearms, in actions against persons (killing and knee capping). Shot pellets may migrate in the body, the blood flow can transport them – a spectacular case was reported by [1], who observed the transport of a shot pellet from the heart into the media cerebral artery creating hemiplegia (Fig. 3.1.3.4A–C).

On radiograms, the depth of penetration allows assessing the range of fire. Another criterion is the spread pattern. However, clothing can alter both! Somehow different are the X-ray findings in shot wounds observed in Latin America: the shot had been self manufactured, as had been the shooting devices; ammunition and shooting device serve the hunt for rabbits and birds, they are sometimes employed against persons. However, the most frequent lesion is due to penetration of the self made ammunition into the body of the shooter, combined with a burst of the self-made shooting device (Fig. 3.1.3.5).

Fig. 3.2.2.2. Bullet emboli into the iliac artery. The point of entry had been the chest; the projectile entered the thoracic aorta and was transported by the blood flow to the iliac artery.

3.2. Firearms

The severity of a gunshot wound is determined by the projectile's form, velocity, movement, and composition/design.

3.2.1. Velocity of the projectile

One can make the difference between gunshot wounds (GSW) due to high velocity bullets and wounds due to low velocity bullets.

Fig. 3.2.2.4. Deflection of a low velocity bullet by the humerus.

Fig. 3.2.3.1. Aspect of injury due to a "dumdum" bullet. The name comes from the town of production.

High velocity GSW: projectiles, which travel with two to three times the speed of sound, produce (when entering the body) a sonic boom in the form of a cone. The cone's apex is the point of entrance of the projectile. The cone ends, when the projectile is decelerated below the speed of sound (Fig. 3.2.1.1A and B).

The destruction concerns the bullet's path and the extension of the sonic boom. A short bullet's path in the body, for example a shot right through arm or leg may result in an exit hole larger than the point of entrance (Fig. 3.2.1.2).

Wound to projectiles which travel with less, low velocity GSW: when a projectile hits the body with less than the speed of sound, no sonic boom comes into existence. The destruction is limited to the projectile's path in the body. Low velocity GSWs are among others those due to bullets of most handguns (Fig. 3.2.1.3 A–C). Unjacketed bullets with high velocity are most dangerous (Fig. 3.2.1.4).

3.2.2. Movements of the projectile

Projectiles that are fired by a gun or pistol rotate around their longitudinal axis; this rotation is decelerated when the impact occurs. The angle, under which the projectile hits the body, and the tissue's resistance change the rotating movement. The projectile may overturn (Fig. 3.2.2.1). When one tries to assess the projectile's movement in the body with the radiogram, one has to have in mind that projectiles can have been passively displaced after the first rest. Examples are the transport of a projectile by the blood stream (Fig. 3.2.2.2); in cavities projectiles, which had been at rest, can be displaced by gravity. Movements of the heart and of skeletal muscles are other reasons of displacement.

A projectile can be deflected by boundary layers; quite common is the deflection by bones, multiple or continuous deflections are the exception, one example is the tangential deflection following the inner contour of the calvarium (Figs. 3.2.2.3 and 3.2.2.4).

A fast moving and overturning projectile induces cavitations in the tissue. Their extent is influenced by form, velocity and angular momentum of the projectile; the extension of the

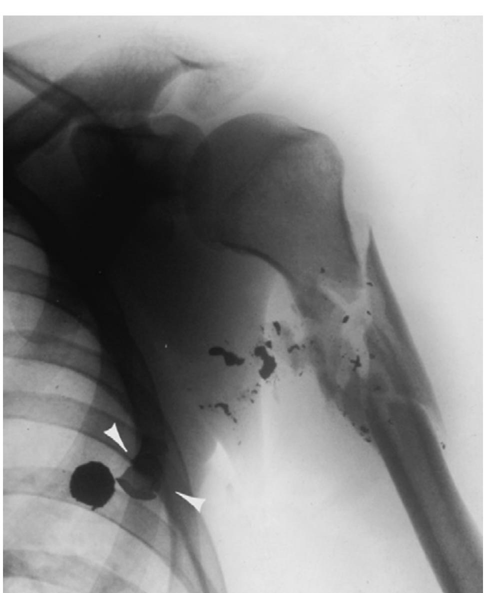

Fig. 3.2.3.2. Injury due to a jacketed projectile. The cover is separated from the contents. The victim was hit only once [1].

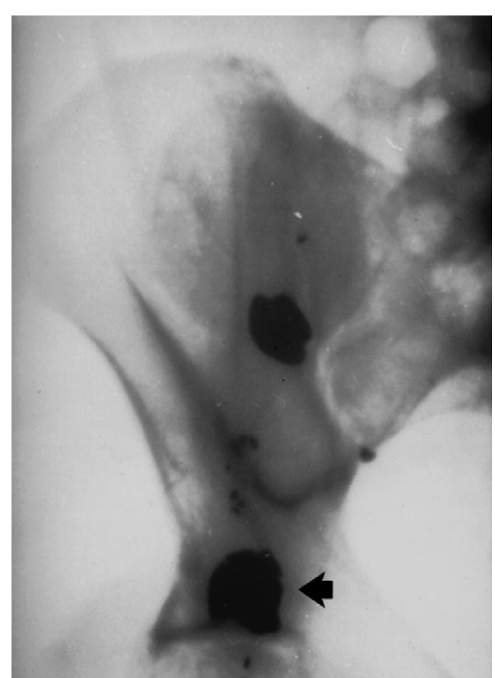

Fig. 3.2.4.1. Projectile with a point, which had been filed off [1].

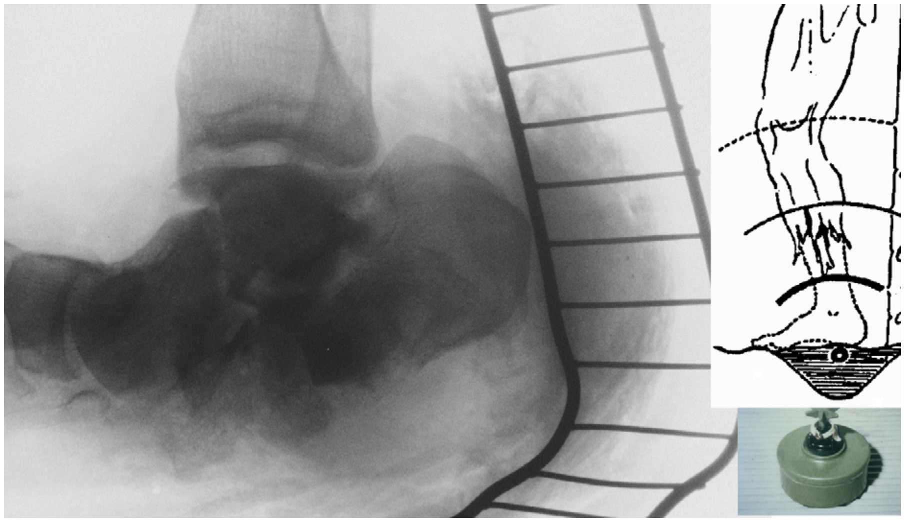

Fig. 3.3.1. A–C: mine lesions.

destruction can sometimes be guessed by "dots", which are small fragments of the jacket (Fig. 3.2.2.1).

3.2.3. Composition of the projectile

A projectile, which disintegrates into fragments on impact, produces a large wound; the victim shows a traumatic shock. The clinic is that of a hit by a high velocity GSW. Projectiles have been designed to produce this effect; an early example has been the dumdum bullet (Fig. 3.2.3.1), which was used by the British forces during the conquest of India. Once hit by a dumdum bullet the victim was incapable to continue fighting, which was of major importance for the British forces, which were outnumbered by their opponents. Today the same effect is achieved by high velocity GSW; however dumdum bullets had been used by the German terrorists, Baader and Meinhof.

Jacketed projectiles are meant to penetrate. The cover creates the opening and the content destroys (Fig. 3.2.3.2).

3.2.4. Form of the projectile

The form of the projectile shapes the flight path. A projectile, which hits the body sidewise, produces a larger wound than with an orthograde hit. A tumbling of the projectile will induce this effect; filing off the projectile's point will provoke overturns on the flight path. The overturning continues in the body (Fig. 3.2.4.1).

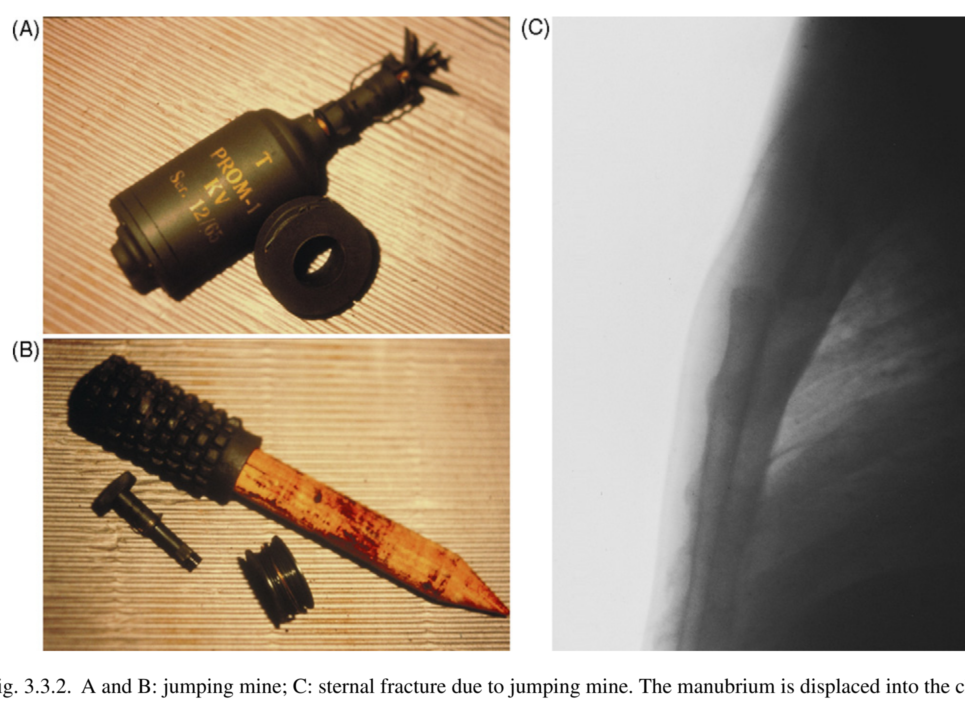

Fig. 3.3.2. A and B: jumping mine; C: sternal fracture due to jumping mine. The manubrium is displaced into the chest.

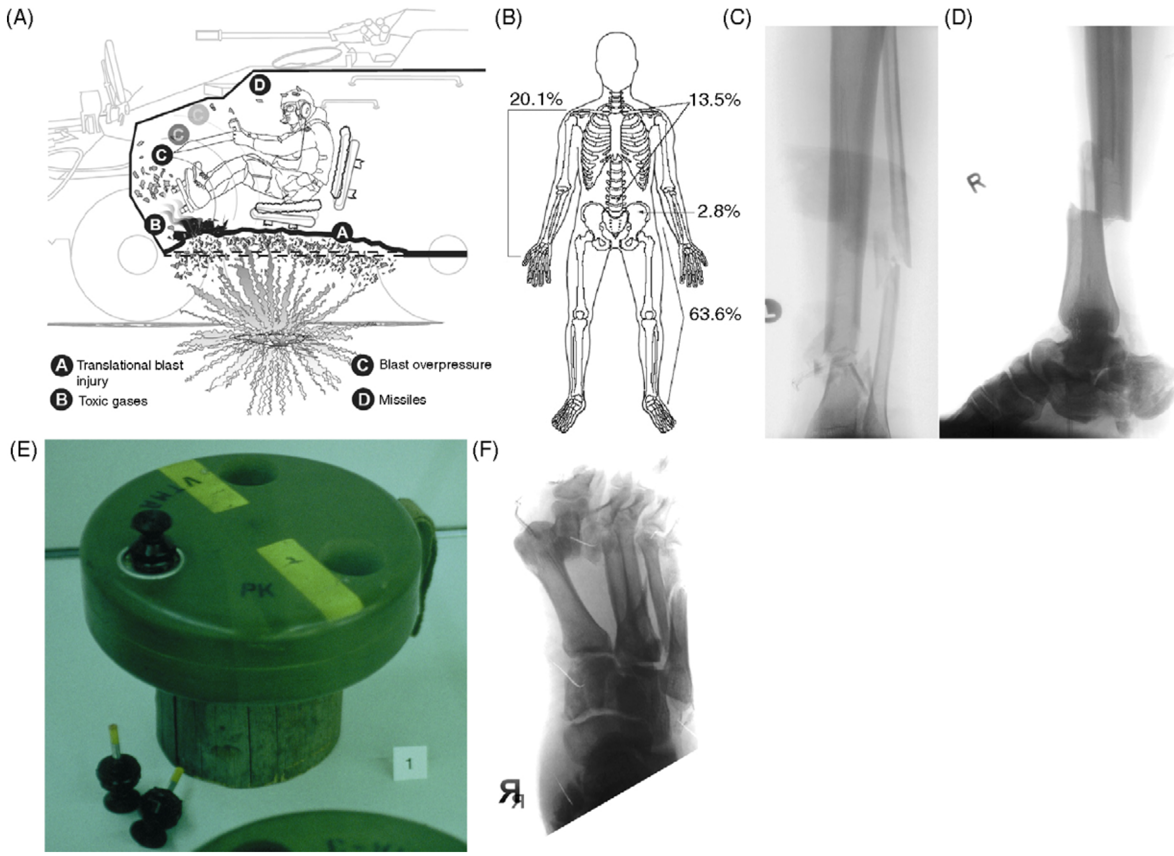

Fig. 3.3.3. A–F: injuries obtained inside vehicles, Afghanistan.

Fig. 3.3.4. A and B: mutilation by mine injury, Afghanistan.

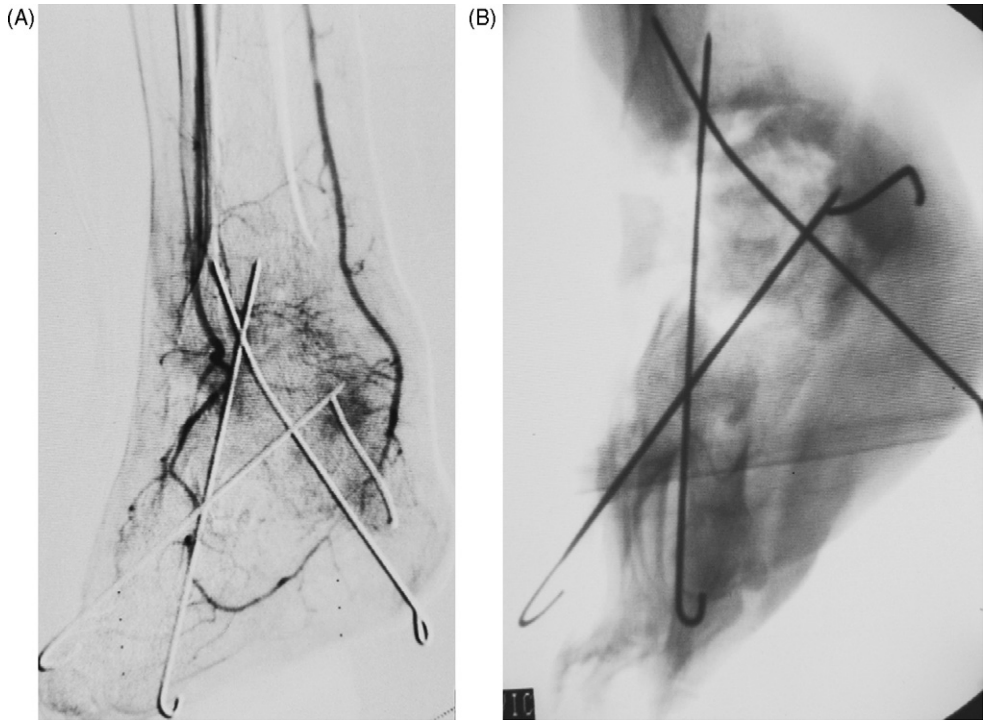

Fig. 3.3.5. A and B: angiography. The arteries are intact, the bones are severely destroyed, Croatia.

3.3. Mines

Antipersonal-mines come in a variety of types. Their explosion usually results in loss of one or both lower limbs, and of the arm during minesweeping. There are several 100 million unremoved mines worldwide (Fig. 3.3.1A–C).

Jumping-mines are being released by a spring in order to "jump" to an altitude of 1–1.5 m for more effective explosion. A touch or a vibration triggers the mechanism. Chest injuries with fractures of the sternum and the ribs result (Fig. 3.3.2A–C).

There are differences between the injuries of persons travelling in armoured cars and those due to antipersonal-mines (Fig. 3.3.3A–F).

To save a mine-injured limb sophisticated medical care is needed; however, even if this care is available, amputation cannot always be avoided (Fig. 3.3.4); Loss and mutilation are the consequence. Singular observations show that the arteries can remain intact even in the neighbourhood of severely destroyed bones (Fig. 3.3.5).

3.4. Explosives, bombs, grenades

Explosions act by heat, pressure and foreign bodies (metal-, glass-, concrete-fragments). The design of the explosive weapon and the victim's distance to the explosion determine the likelihood and the type of injury (Fig. 3.4.1A and B).

Pressure waves (blast) can damage the lungs by contusion and laceration resulting in lung hemorrhage. The radiograph shows increased lung opacification due to hemorrhage; hemoptysis is common. Bones may fracture from the blast or from direct contact with bomb-fragments or other falling objects nearby; this also goes for soft-tissue damage, severe laceration included. The CNS may also suffer severely; and spinal cord damage oftentimes leads to paraplegia (Figs. 3.4.2–3.4.5)

4. Discussion

In war, the radiogram is first of all part of the medical care; it shows the lesion, its extension, serves for planning surgery and estimating the prognosis.

4.1. Radiograms as document and source of intelligence

Less known is that the radiogram may serve as document, which can be evaluated by a third person, not participating in the treatment of the patient. This could be of importance if a conflict party is accused to have employed forbidden weapons, or weapons whose use is considered cruel. This may be valid for cluster bombs and dumdum projectiles. In such a context the radiogram may be used as a weapon of propaganda warfare:

Recently, Israel has been accused to have employed cluster bombs in Lebanon, - radiograms could have corroborated the accusation; on the other hand the Hezbollah has been accused to have fired Kassam rockets against civilian targets.

The Chinese government had been accused to have used dumdum projectiles against protesters. Radiograms could have served as prove; they were not published. However, the effect of a dumdum projectile is nearly the same as that of a high velocity bullet both induces a rapid shock of the victim; he/she will

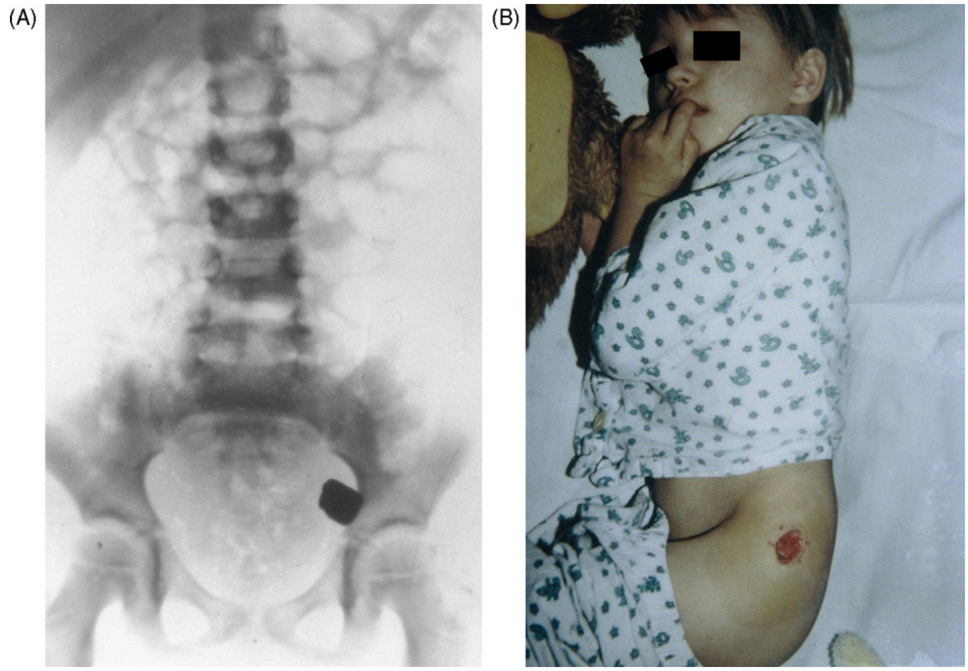

Fig. 3.4.1. A and B: fragments in the pelvis, Croatia.

not be able to continue the protest or the fighting. In general, projectiles, which disintegrate on impact, produce large wounds and shock, the radiology of injuries due to such projectiles can be observed in forensic medicine on victims killed with hunting rifles and on victims of GSW in the Near East [1].

In war, radiograms may contain information about the arms the opponent employs and about the weapons' range; this intelligence may serve to plan the future deployment of military and sanitary units.

4.2. Wounds to missile firing arms to explosives

The United States are considered the example par excellence in personal use of the gun by its citizens. The right to own and bear arms is guaranteed in the US Constitution. The use of this right contributes to the high number of GSW in the US compared to those countries where gun ownership is tightly controlled. The favourable results of such tight controls have been shown statistically.

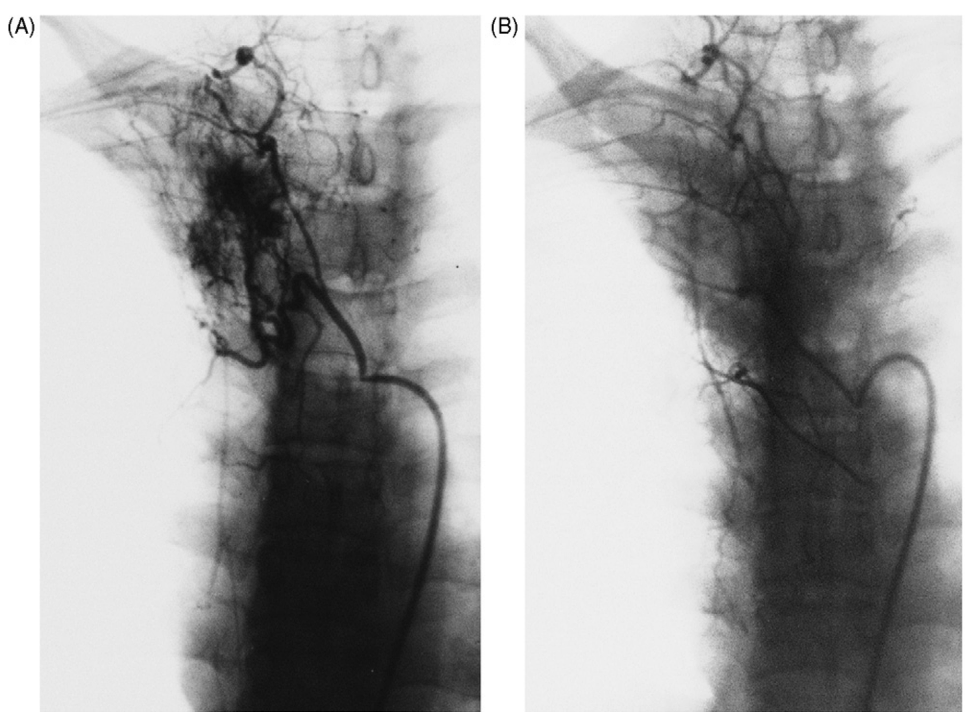

Fig. 3.4.2. Pulmonary laceration by shockwave due to bomb detonation; transcatheral occlusion of the bleeding bronchial artery. Vietnam.

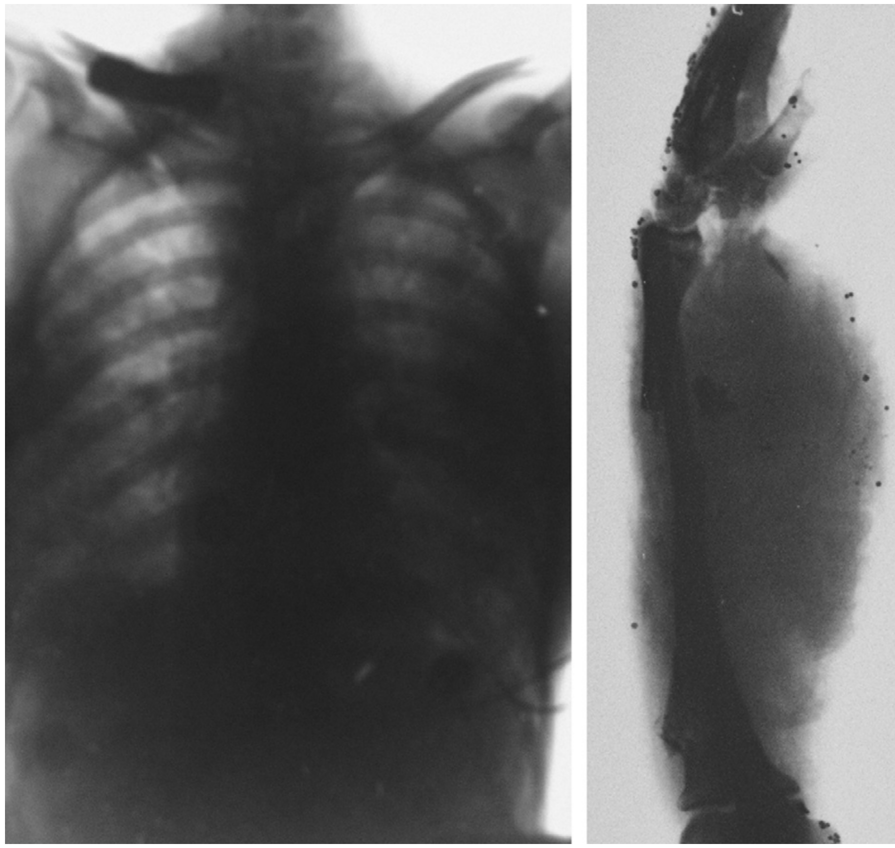

Fig. 3.4.3. A and B Opacification of both lungs. Lung-laceration due to blast and soft tissue damage due to blast.

Fig. 3.4.4. Splinters damaging the spinal cord, paraplegia. MRI, Croatia.

Evaluation of the gun and gunshot wounds can be traced back to Röntgen, who examined his shotgun with the X-rays and found a few flaws, thus introducing the concept of nondestructive testing. Within two weeks of Röntgen's announcement of his discovery, X-rays were used in Canada to locate a bullet fired into the leg of Tolsen Cunning by George Holder, who subsequently was imprisoned for the assault. Within three months of Röntgen's announcement, X-rays were employed to locate the bullets fired into the head of Elizabeth Ann Hartley by her murderous husband, Hargreaves [1].

Weapons are used and developed for military purposes. This creates a conflict with medical ethics. One example has been the design of dumdum bullets: the victim shall not be able to continue fighting; taking care for him must bind extra-capacities. These goals are obtained by inflicting large wounds and shock. These are achieved by bullets disintegrating upon body-contact, (dumdum), hitting the body with the missile's side rather than the tip, or by causing a hypersonic shock wave in the tissue, all facilitated by the bullet's design.

Radiograms furnish basic information about the used weapons and their effects:

Splinters may be large or small, they may contain parts of the bullet's coat or core. Projectile- and grenade-splinters may look similar on radiographs. Large fragments and typical patterns facilitate the projectile's recognition or even the weapon it was fired with.

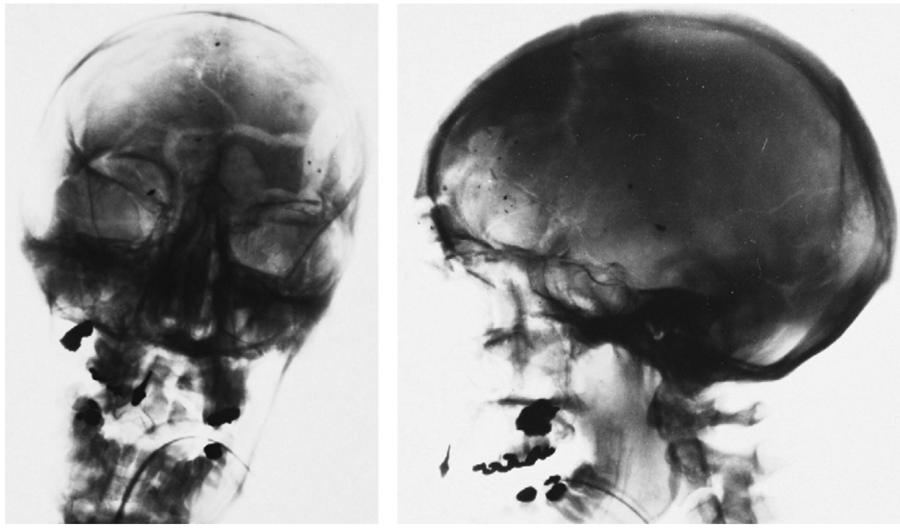

Fig. 3.4.5. Cranial fractures due to blast.

In GSW, the radiograms show the following [1,2,4–6]:

- location of the bullet;
- number of bullets;
- calibre of bullets;
- angel and direction of fire;
- discovering a concealed gunshot wound;
- weapons ballistics;
- types of bullets.

In injuries due to explosives, a radiogram visualizes direct effects of the blast such as [3]:

- contusion or laceration of the lung;
- foreign bodies from the bomb;
- foreign bodies from other sources (e.g., automobile fragments) transferred by the explosion;
- fractures and dislocations of bones;
- fractures and perforations of visceral organs;
- arterial damage.

4.3. Conclusion

The radiogram remains part of the medical care, however, it contains information, which may have importance for war actions. The military physician may be concerned in planning the care of victims, the officer may be interested in knowing which weapons have been and will be used. The radiogram can be employed in the propaganda of war. This implies the assumption that images will not lie; however, the correct reading and interpretation of a radiogram depends on knowledge of the employed arms and their effects.

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